

Editorial

Marketing Science, Models, Monopoly Models, and Why We Need Them

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Mathematical Models and *Marketing Science*

Despite popular belief, the marketing discipline was an offshoot of economics (Bartels 1951, Sheth et al. 1988). Early researchers, often educated in economics, felt economics was preoccupied with variables such as prices and costs. They focused on other variables. They also investigated marketing as a productive activity (i.e., adding value) by adopting different sets of assumptions other than economics (Bartels 1976). Were profit variations across firms caused entirely by random exogenous factors beyond managerial control, marketing would have no “value-added,” and the discipline of marketing would have diminished purpose.

Mathematical marketing models appeared much later as a precise, logical and scientific way to “add value.” By 1970, researchers developed mathematical models for many purposes, including better forecasting, integration of data, and understanding of markets. Just a few of the many high-impact pre-1970 marketing models include those of Bass (1969a, 1969b), Bass and Parsons (1969), Cox (1967), Frank et al. (1965), Friedman (1958), Green and Rao (1970), Kuehn (1962), Little and Lodish (1969), Little et al. (1963), Morrison (1969), Telser (1960, 1962), Urban (1969), Vidale and Wolfe (1957), and Winters (1960).

Today, mathematical models in *Marketing Science* cover many topics. Just a few examples (presented alphabetically) include: advance selling (Xie and Shugan 2001); creating customer satisfaction (Anderson and Sullivan 1993); direct marketing (e.g., Rossi et al. 1996); forming empirical generalizations (e.g., Mahajan et al. 1995); identifying first-mover advantages (e.g., Kalyanaram et al. 1995); implementing a wide range of marketing instruments (e.g., Padmanabhan and Rao 1993, Shaffer and Zhang 1995); modeling customer heterogeneity (Gonul and Srinivasan 1993); implementing the new empirical IO (Kadiyali et al. 2000); creating new product development (e.g., Griffin and Hauser 1993); understanding channels (e.g., Messinger and Narasimhan 1995); understanding dynamic brand choice (e.g., Erdem and Keane 1996); and understanding market evolution (e.g., Dekimpe and Hanssens 1995). Mathematics, as the language of science, allows interplay between empirical and theoretical research (Hauser 1985).

Marketing Science publishes both empirical and theoretical mathematical models. Precise definitions of mathematical marketing models are controversial (Leeflang et al. 2000). We could narrowly define models as mathematical optimizations of marketing variables. However, *Marketing Science* adopts a more generic definition, which includes mathematical representations that answer important research questions in marketing. That definition allows publication of mathematical models from a multitude of disciplines, including Management Science, Statistics, Econometrics, Economics, Psychometrics, and Psychology.

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Note that the following discussion only considers models used by researchers. Models for use by managers are also important. Little (1970) discusses desirable characteristics (e.g., adaptiveness, control, ease of communication) for managerial models. Lilien (1975) finds that different uses (e.g., long-range planning versus short-range scheduling) require different models.

Mathematical Models and Assumptions

Both theoretical and empirical models seek to parsimoniously describe reality and clarify prominent relationships. We already have reality with complete detail; we need models to simplify reality. Perhaps, the only advantage of a model over reality is simplicity. Of course, simplicity is not a goal but only a property of a model.

The essence of modeling is making approximating assumptions creating parsimony (Thorburn 1915) with the prudent application of Occam's razor (i.e., the law of parsimony). Models can only accommodate a limited amount of complexity. So, we must save that complexity for the study of the central research question. We build Marketing Science models to omit distracting details (i.e., variables or factors) of reality so that we can create more concise representations of reality for description, prediction, or optimization. Modeling is often more the art of deciding which details to exclude from the model, rather than which details to include.

Choosing the right level of detail involves the well-known compromise between generality (i.e., fit) and robustness (i.e., predictive accuracy). Models that explain all observations often predict poorly, either because they overfit or they make weak (i.e., more ambiguous) predictions. Stronger approximating assumptions allow cleaner predictions (albeit for fewer situations). Less parsimonious models often provide weaker answers and, most notably, are less amenable to testing.

To advance knowledge, models must provide sufficient clarity to produce unambiguous testable

implications (whether prescriptive or predictive). Testable implications allow us to separate the good models from the bad (Popper 1959). Moreover, separating competing models is what causes progress (e.g., Platt 1964, Armstrong et al. 2001). Dogmatic acceptance of one model (e.g., because it came first or it is too general to refute) can deter progress. We must compare models based on the validity of their implications.

When a body of literature agrees on some strong common acceptable assumptions, testing becomes possible. Amazing empirical and theoretical progress follows (e.g., see Myerson 1999). Strong assumptions produce powerful models. For example, consider the strong assumptions that economic systems are in equilibria (e.g., static noncooperative Nash equilibria) or that empirical relationships are inherently linear. Having competing sets of strong acceptable assumptions is essential for progress.

Hence, progress requires different sets of strong acceptable assumptions that have different implications.

Which Assumptions to Make

To make strong assumptions we must omit details, and the modeling objective (Lilien 1975, Little 1970) determines which details to omit.

Consider highway maps sold at numerous retail stores. Despite similarities, maps of the same geographic region often dramatically differ. Only some maps show local attractions. Only some show every street. Only some show vast geographic regions. Only some show bus and train routes. Only some maps show branded gas and food outlets. No map is all inclusive, because all-inclusive maps are unreadable and lack the value of modeling, i.e., simplification.

These maps provide different models or parsimonious paramorphic representations (Einhorn et al. 1979) of the same geographic reality. Each map makes important omissions (i.e., makes important assumptions) by ignoring some important aspects of the terrain. The need to read and use each map constrains potential generality. Each map is useful for

only some objectives, and no map dominates all others.

There are wrong maps that show incorrect locations. However, there are also numerous correct maps. Each map assumes that different aspects of the geographic terrain (e.g., roads, streets, train stations) are irrelevant to the objectives of the user. No scientific method can determine whether maps including only local bus routes are superior to maps including only local streets or maps including only interstate highways. Only the modeler's objectives dictate superiority. The best model depends on whether the objective is to navigate through an area by train, by car, or by foot.

Hence, to evaluate a model, the modeling objective is critical. The objectives tell us how to simplify and what to omit. Now, let us consider one implication of this reasoning.

The Advantages of Monopoly Models

We said modeling objectives dictate appropriate model omissions. Akin to our maps, different past models in *Marketing Science* use different variables, including prices, product attributes, customer heterogeneity, sales force decisions, prior beliefs, promotions, coupons, competitive response, channels, advertising, targeting, and many more details of marketing systems, while omitting most other variables. Sometimes, publication occurs because articles successfully argue that omissions are not critical to the article's objectives. At other times, publication occurs because articles include details that reviewers deemed important based on tradition, current popularity, or the reviewer's own research agenda. Reviewers sometimes object to the omission of details that may be essential to the reviewer's (rather than the author's) research objective.

Consider the detail of competition as an example. Competition is certainly both critical and integral to many research objectives. Some models (e.g., those of brand loyalty, product positioning, and consumer choice) require competitive variables. Unfortunately,

the current methods (e.g., requiring a unique competitive equilibrium) for including competition in (both theoretical and empirical) marketing models are expensive. They allocate complexity in specific directions and, sometimes, the required assumptions force the omission of other important variables that are required for other research objectives.

For example, current competitive models often assume that decision makers are currently making optimal decisions at equilibrium and know that others are doing the same and that best decision responses will be made (Rubinstein 1982; Binmore et al. 1986). These assumptions are very powerful (Moorthy 1985). They produce specific testable predictions. As argued earlier, strong assumptions provide important benefits for some objectives while being inappropriate for other objectives.

Unfortunately, these assumptions inhibit the objective of advising decision makers at equilibrium on actions to improve their positions. It is difficult to advise players who already act optimally or to explore improvements at equilibrium. Hence, although including competition is desirable, current methods often force assumptions conflicting with other objectives.

Assuming pre-existing optimal behavior requires predicted behavior to match empirically observed behavior. We are unable to learn from empirical comparisons between weak and strong performers. We are unable to use data to improve behavior.

Given this argument, we might ask when is it appropriate to assume optimal behavior. The answer is the same as with any other assumption. An assumption is appropriate when it provides a good approximation within the context of the research objective. Different objectives often require different models with different omissions. Assuming optimal behavior to model competition is sometimes appropriate and sometimes not.

For example, suppose our objective is predicting the outcome of a chess game, a football game, or a war. Assuming pre-existing optimal behavior by players, coaches, and military generals provides required predictions as functions of exogenous parameters. Things change, however, when our objective

becomes advising players, coaches, or military generals. It appears contradictory to assume that those we seek to advise are already making optimal decisions. Indeed, the intent of much research in marketing is to improve (i.e., change) the actions of decision makers. It seems inappropriate, for example, for all new product models to assume that all successful products already exist or for all budgeting models to assume that all budgets are already optimal. Similarly, it seems inappropriate for all pricing models to assume that prices are already optimal.

This argument makes no claim that one objective is better than another—Providing advice to decision makers and making predictions about decision-makers are both important. Unfortunately, the same model (i.e., the same approximating assumptions) may be unable to accomplish both objectives.

When a model intends, for example, to provide directions to drivers taking car trips, it is foolish to assume that all drivers already know the best route. In contrast, when the model intends to construct highways, an appropriate approximating assumption might be that most drivers will take the best routes. If the model seeks to help congress determine optimal highway budgets, the model might assume optimal spending of the budget. Hence, objectives dictate appropriate assumptions. The assumption about optimal behavior is an appropriate approximation for some but not for all objectives. It often depends on whom we intend to advise.

The same conclusion applies to purely descriptive or methodological models. Descriptive models of celestial bodies require different approximating assumptions than do descriptive models of supersymmetry. Methods for estimating the weight of gold bars require different approximating assumptions than do methods for estimating the weights of buildings, planets, or molecules.

These remarks are not intended to suggest that the assumption of a competitive equilibrium has little value: It has monumental value. The assumption of a competitive equilibrium is particularly valuable for answering many research questions, including the impact of regulation or public policy on the players who adopt optimal behavior. (Of course,

don't assume that regulation is already optimal.) It also has value for predicting how markets will develop and understanding how external shocks might impact markets. The only argument made here is that incorporating competition by assuming optimal behavior currently requires a set of approximating assumptions that often conflict with the objective of advising marketing decision makers. The research objective dictates the appropriate assumptions.

The conclusion is that we should sometimes embrace monopoly models. The strong approximating assumption of no competitive response is sometimes better than the approximating assumption of pre-existing optimal behavior. This conclusion might seem backward. *Marketing Science* has spent the last 20 years moving from monopoly models to competitive equilibrium models. Interestingly, when we look at the origin of these models (i.e., the economic literature), we see that monopoly models persist.

Some of the most popular economic models, with many marketing applications, model the decision maker as a monopolist (although competition almost always exists for others). Principal-agent models with risk sharing and imperfect information (Holmstrom 1979) usually model the principal as a monopolist. Auction models (Vickrey 1961, Milgrom and Weber 1982) usually model the auctioneer as a monopolist. Contracting models and compensation models (Nalebuff and Stiglitz 1983, Green and Stokey 1983) usually model the employer as a monopolist. Models of bundling and tying agreements (Whinston 1990) often model the seller as a monopolist. Franchising models (Brickley and Dark 1987, Rubin 1978) usually model the franchisor as a monopolist. Entry deterrent models often consider deterrence by a monopolist (Milgrom and Roberts 1982). Economic models of consumers often exclude competition (Strotz 1956, Thaler and Shefrin 1981). Of course, one of the highest-impact articles ever published in *Econometrica* failed to consider competition (i.e., Kahneman and Tversky 1979). Although these citations allude to the classic articles, recent articles (e.g., see Klemperer 1999 and Riley 2001 for excellent reviews) tend to follow the same pattern. Articles that can help decision makers tend to treat

them as monopolists (e.g., Bester and Ritzberger 2001, Cason and Sharma 2001, Choi and Stefanadis 2001, Gilbert 2000), whereas articles seeking to explain behavior do not (e.g., Bulow et al. 1999). The same is true in the operations literature, which considers topics such as supply chain management, manufacturing strategy, inventory decisions, and pricing decisions, with minimal consideration of competitive equilibria.

In sum, *Marketing Science* urges reviewers to carefully evaluate the assumptions and model simplifications (whether empirical, methodological, theoretical, or substantive) within the context of the manuscript's objectives. Omitting competition alone is insufficient grounds for rejection for some research objectives.

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